US005604904A

United States Patent [19]

Kini

[11] **Patent Number: 5,604,904**

[45] **Date of Patent: Feb. 18, 1997**

[54] **METHOD AND APPARATUS FOR ACCESSING SYSTEM MANAGEMENT FUNCTIONS OF A COMPUTER SYSTEM**

[75] Inventor: **Vittal Kini**, Aloha, Oreg.

[73] Assignee: **Intel Corporation**, Santa Clara, Calif.

[21] Appl. No.: **312,145**

[22] Filed: **Sep. 26, 1994**

[51] **Int. Cl.^{6}** **G06F 9/40**

[52] **U.S. Cl.** **395/682**

[58] **Field of Search** 395/700, 650

[56] **References Cited**

U.S. PATENT DOCUMENTS

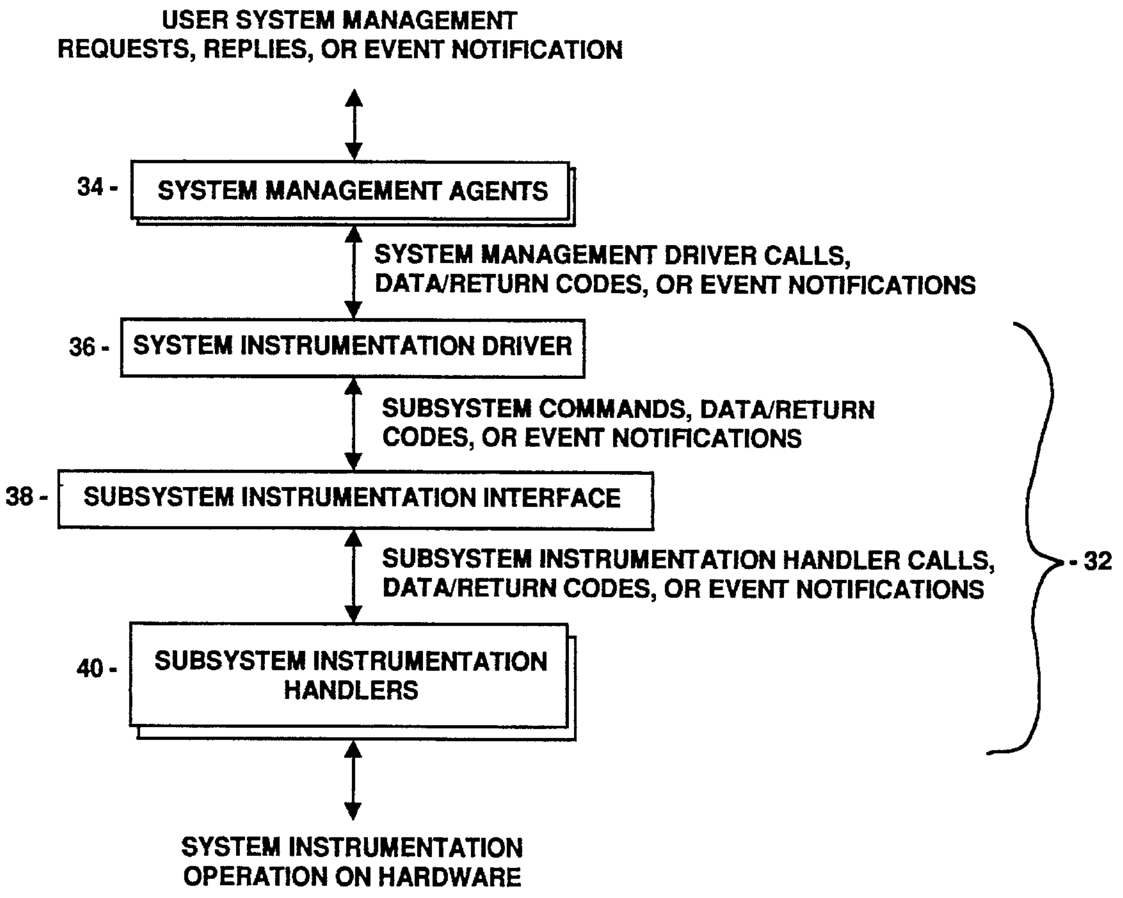
4,750,116	6/1988	Pham et al.	395/700
4,862,349	8/1989	Foreman et al.	395/700
5,339,437	8/1994	Yuen	395/700
5,430,836	7/1995	Wolf et al.	395/155
5,522,076	5/1996	Dewa et al.	395/700

Primary Examiner—Kevin A. Kriess
Attorney, Agent, or Firm—Blakely, Sokoloff, Taylor & Zafman

[57] **ABSTRACT**

A system instrumentation driver, a subsystem instrumentation interface, and a number of subsystem instrumentation handlers, are provided to a computer system platform for accessing system management features and functions of the platform. The system instrumentation driver is operating system specific; it is used to issue subsystem commands to the subsystem instrumentation interface, in response to system management calls from system management agent software. The subsystem instrumentation interface is platform, operating system as well as subsystem implementation independent; it is used to map each subsystem command into one or more invocations of the appropriate subsystem instrumentation handlers. The subsystem instrumentation handlers are platform and subsystem specific; they are used to access the vadous system management features and functions of the platform. Together, the system instrumentation driver, the subsystem instrumentation interface, and the subsystem instrumentation handlers, cooperate to provide accesses to the system management features and functions of the platform in a more efficient and cost effective manner.

34 Claims, 10 Drawing Sheets


USER SYSTEM MANAGEMENT REQUESTS, REPLIES, OR EVENT NOTIFICATION
34 - SYSTEM MANAGEMENT AGENTS
SYSTEM MANAGEMENT DRIVER CALLS, DATA/RETURN CODES, OR EVENT NOTIFICATIONS
36 - SYSTEM INSTRUMENTATION DRIVER
SUBSYSTEM COMMANDS, DATA/RETURN CODES, OR EVENT NOTIFICATIONS
38 - SUBSYSTEM INSTRUMENTATION INTERFACE
SUBSYSTEM INSTRUMENTATION HANDLER CALLS, DATA/RETURN CODES, OR EVENT NOTIFICATIONS
40 - SUBSYSTEM INSTRUMENTATION HANDLERS
- 32
SYSTEM INSTRUMENTATION OPERATION ON HARDWARE

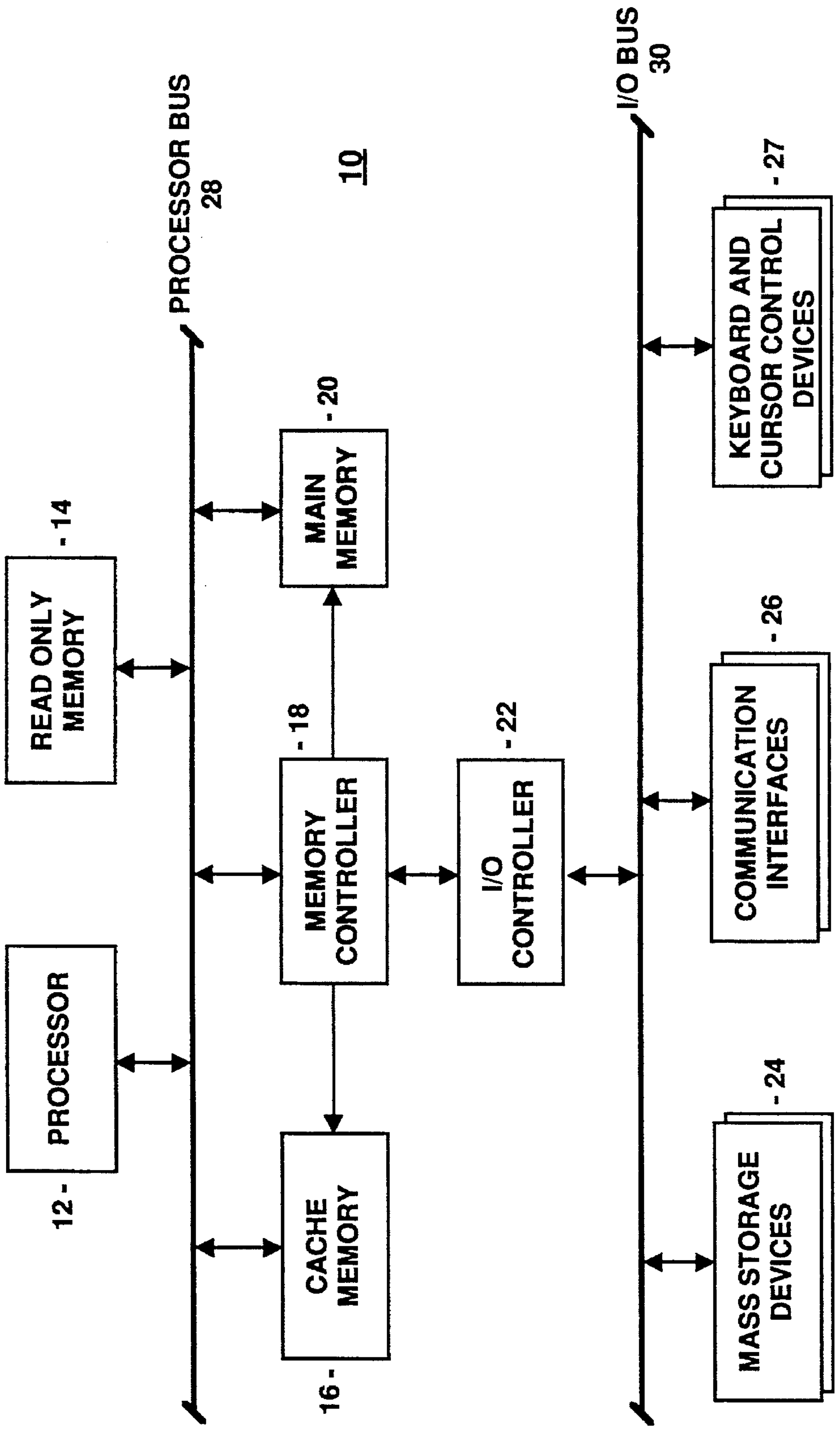

PROCESSOR BUS 28
I/O BUS 30
10
PROCESSOR
12
READ ONLY MEMORY
14
CACHE MEMORY
16
MEMORY CONTROLLER
18
MAIN MEMORY
20
I/O CONTROLLER
22
MASS STORAGE DEVICES
24
COMMUNICATION INTERFACES
26
KEYBOARD AND CURSOR CONTROL DEVICES
27

Figure 1

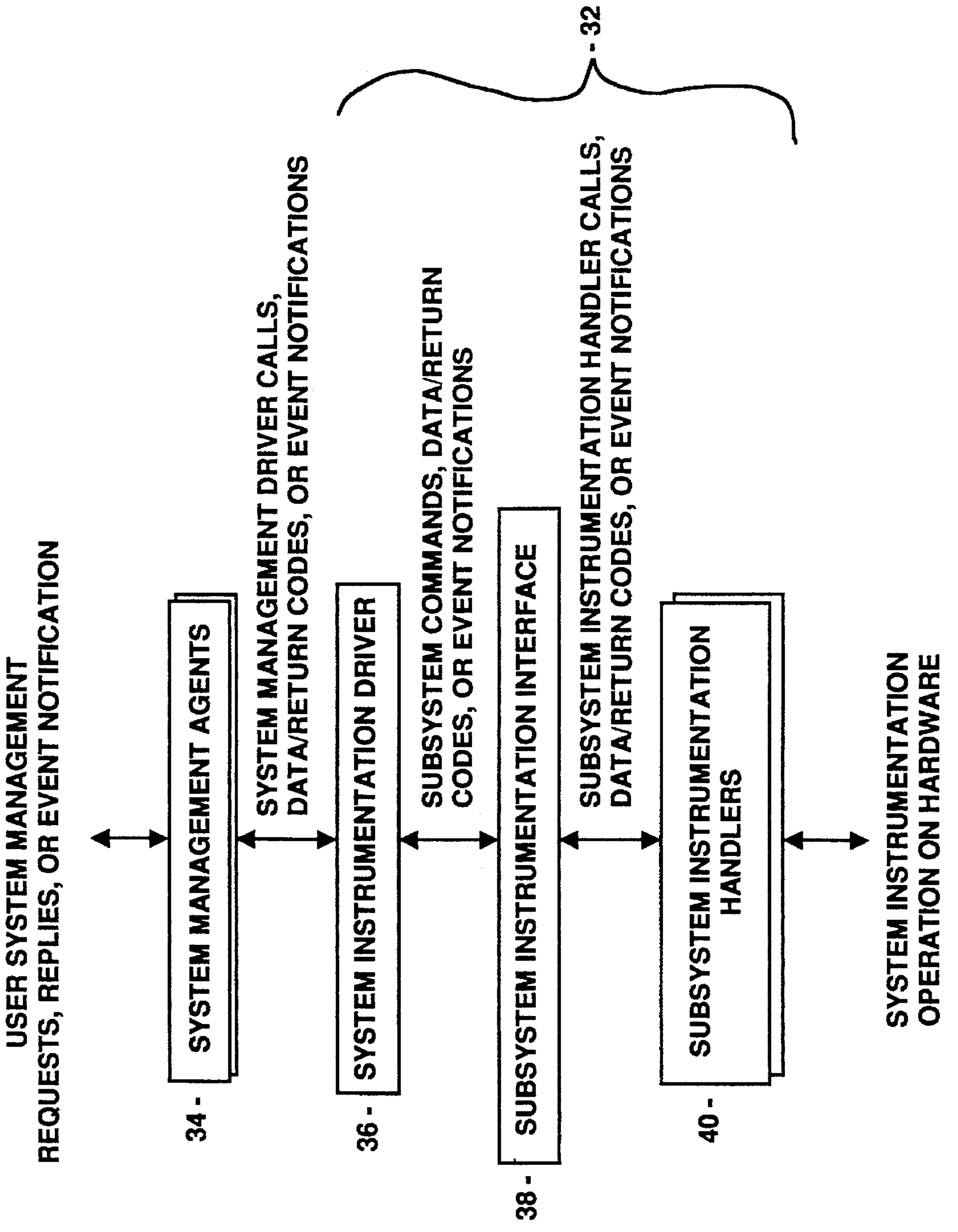
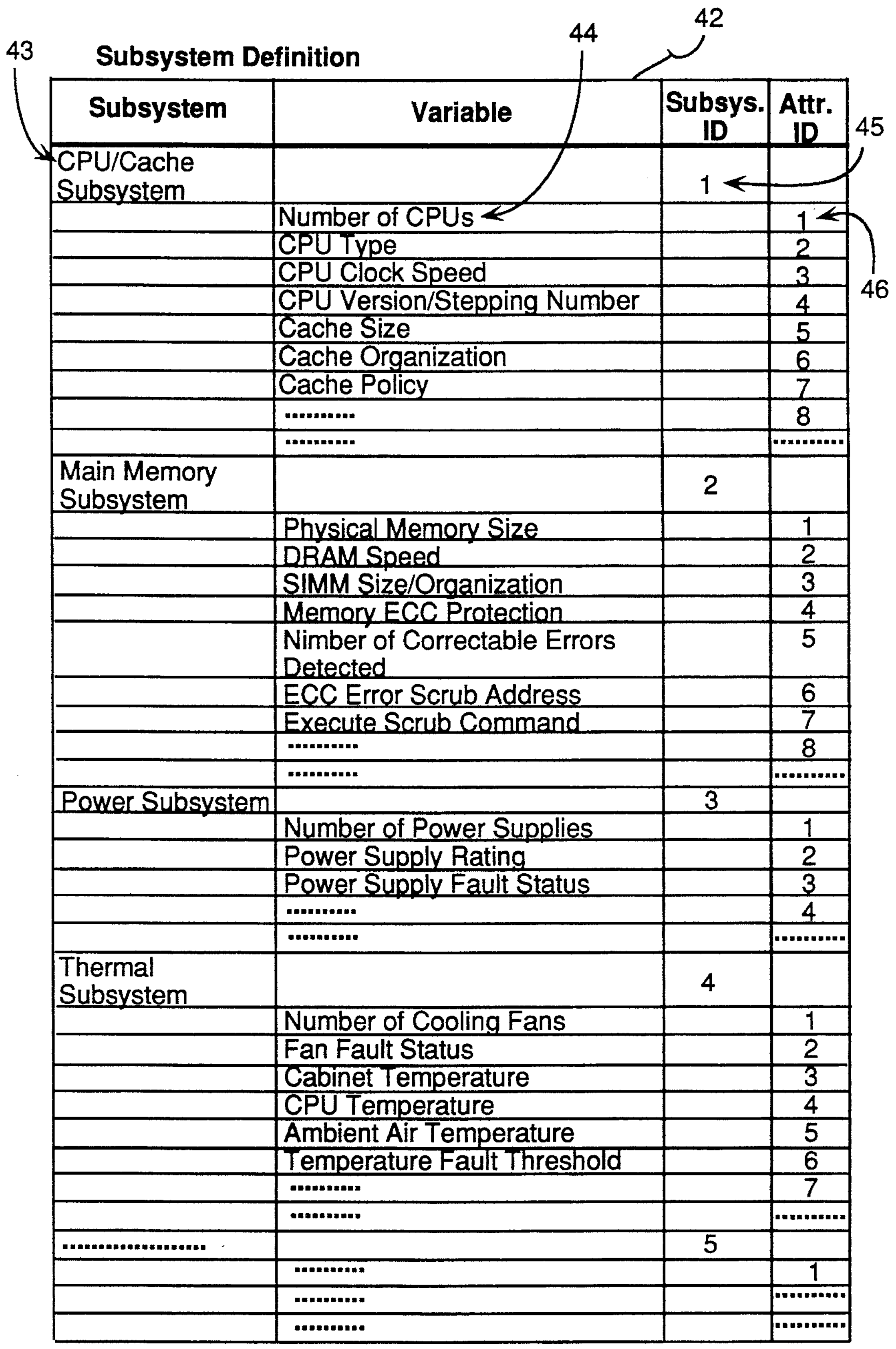

USER SYSTEM MANAGEMENT REQUESTS, REPLIES, OR EVENT NOTIFICATION
34
SYSTEM MANAGEMENT AGENTS
SYSTEM MANAGEMENT DRIVER CALLS, DATA/RETURN CODES, OR EVENT NOTIFICATIONS
36
SYSTEM INSTRUMENTATION DRIVER
SUBSYSTEM COMMANDS, DATA/RETURN CODES, OR EVENT NOTIFICATIONS
38
SUBSYSTEM INSTRUMENTATION INTERFACE
SUBSYSTEM INSTRUMENTATION HANDLER CALLS, DATA/RETURN CODES, OR EVENT NOTIFICATIONS
40
SUBSYSTEM INSTRUMENTATION HANDLERS
SYSTEM INSTRUMENTATION OPERATION ON HARDWARE
32

Figure 2


43
44
42
45
46

Subsystem Definition

Subsystem	Variable	Subsys. ID	Attr. ID
CPU/Cache Subsystem		1	
	Number of CPUs		1
	CPU Type		2
	CPU Clock Speed		3
	CPU Version/Stepping Number		4
	Cache Size		5
	Cache Organization		6
	Cache Policy		7
	....		8
	....		....
Main Memory Subsystem		2	
	Physical Memory Size		1
	DRAM Speed		2
	SIMM Size/Organization		3
	Memory ECC Protection		4
	Nimber of Correctable Errors Detected		5
	ECC Error Scrub Address		6
	Execute Scrub Command		7
	....		8
	....		....
Power Subsystem		3	
	Number of Power Supplies		1
	Power Supply Rating		2
	Power Supply Fault Status		3
	....		4
	....		....
Thermal Subsystem		4	
	Number of Cooling Fans		1
	Fan Fault Status		2
	Cabinet Temperature		3
	CPU Temperature		4
	Ambient Air Temperature		5
	Temperature Fault Threshold		6
	....		7
	....		....
....		5	
	....		1
	....		....
	....		....

Figure 3

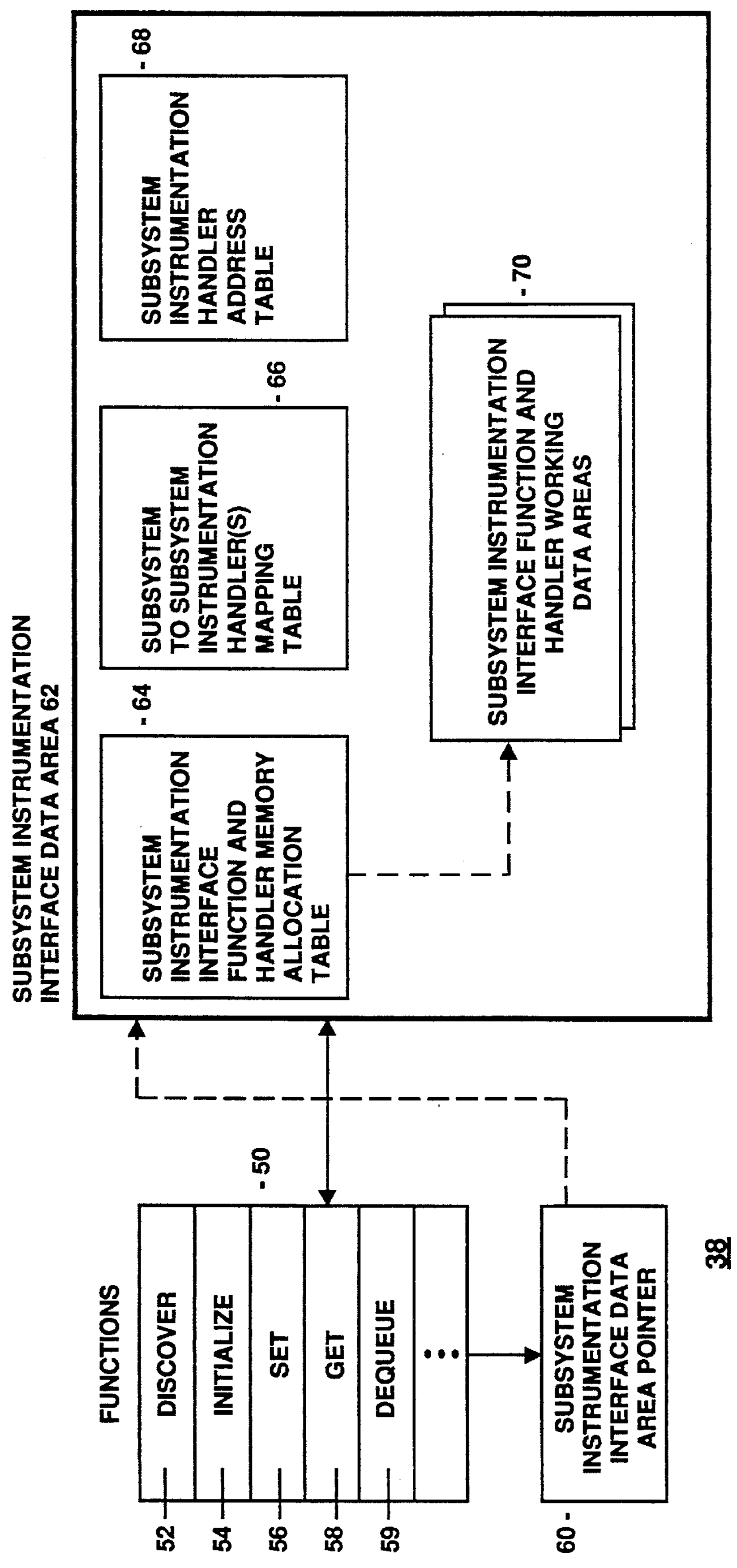

FUNCTIONS
DISCOVER
INITIALIZE
SET
GET
DEQUEUE
...
52
54
56
58
59
50
SUBSYSTEM INSTRUMENTATION INTERFACE DATA AREA POINTER
60
38
SUBSYSTEM INSTRUMENTATION INTERFACE DATA AREA 62
SUBSYSTEM INSTRUMENTATION INTERFACE FUNCTION AND HANDLER MEMORY ALLOCATION TABLE
64
SUBSYSTEM TO SUBSYSTEM INSTRUMENTATION HANDLER(S) MAPPING TABLE
66
SUBSYSTEM INSTRUMENTATION HANDLER ADDRESS TABLE
68
SUBSYSTEM INSTRUMENTATION INTERFACE FUNCTION AND HANDLER WORKING DATA AREAS
70

Figure 4

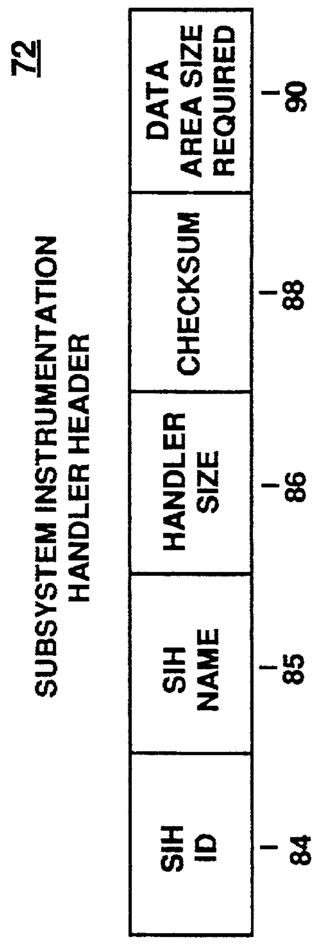


Figure 5c

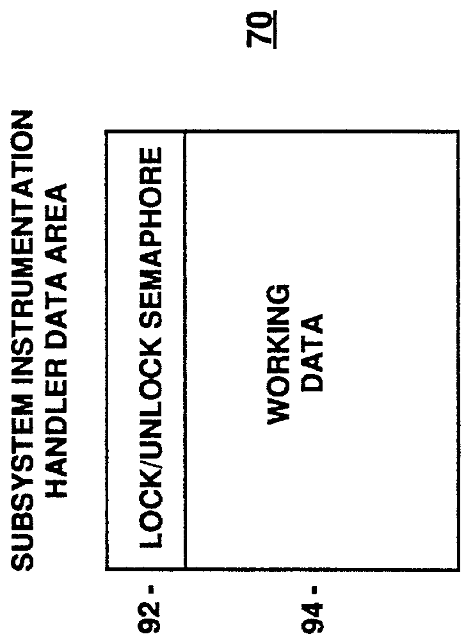


Figure 5b

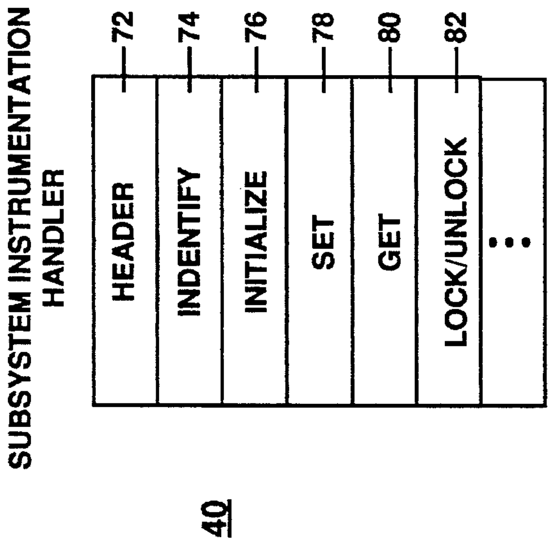
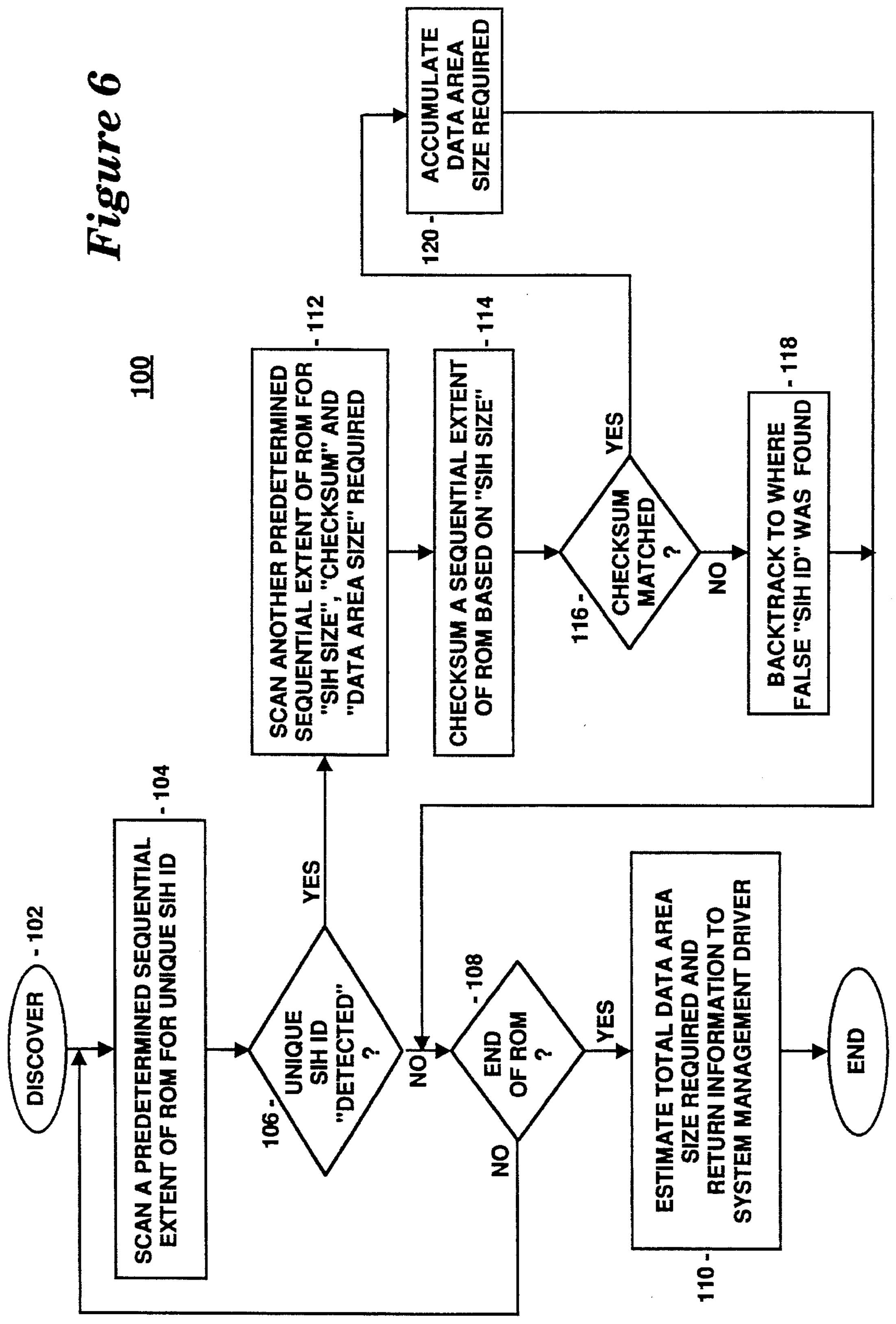


Figure 5a

Figure 6


100
DISCOVER - 102
SCAN A PREDETERMINED SEQUENTIAL EXTENT OF ROM FOR UNIQUE SIH ID - 104
106 - UNIQUE SIH ID "DETECTED" ?
YES
NO
SCAN ANOTHER PREDETERMINED SEQUENTIAL EXTENT OF ROM FOR "SIH SIZE", "CHECKSUM" AND "DATA AREA SIZE" REQUIRED - 112
CHECKSUM A SEQUENTIAL EXTENT OF ROM BASED ON "SIH SIZE" - 114
116 - CHECKSUM MATCHED ?
YES
NO
120 - ACCUMULATE DATA AREA SIZE REQUIRED
BACKTRACK TO WHERE FALSE "SIH ID" WAS FOUND - 118
END OF ROM ? - 108
YES
NO
110 - ESTIMATE TOTAL DATA AREA SIZE REQUIRED AND RETURN INFORMATION TO SYSTEM MANAGEMENT DRIVER
END

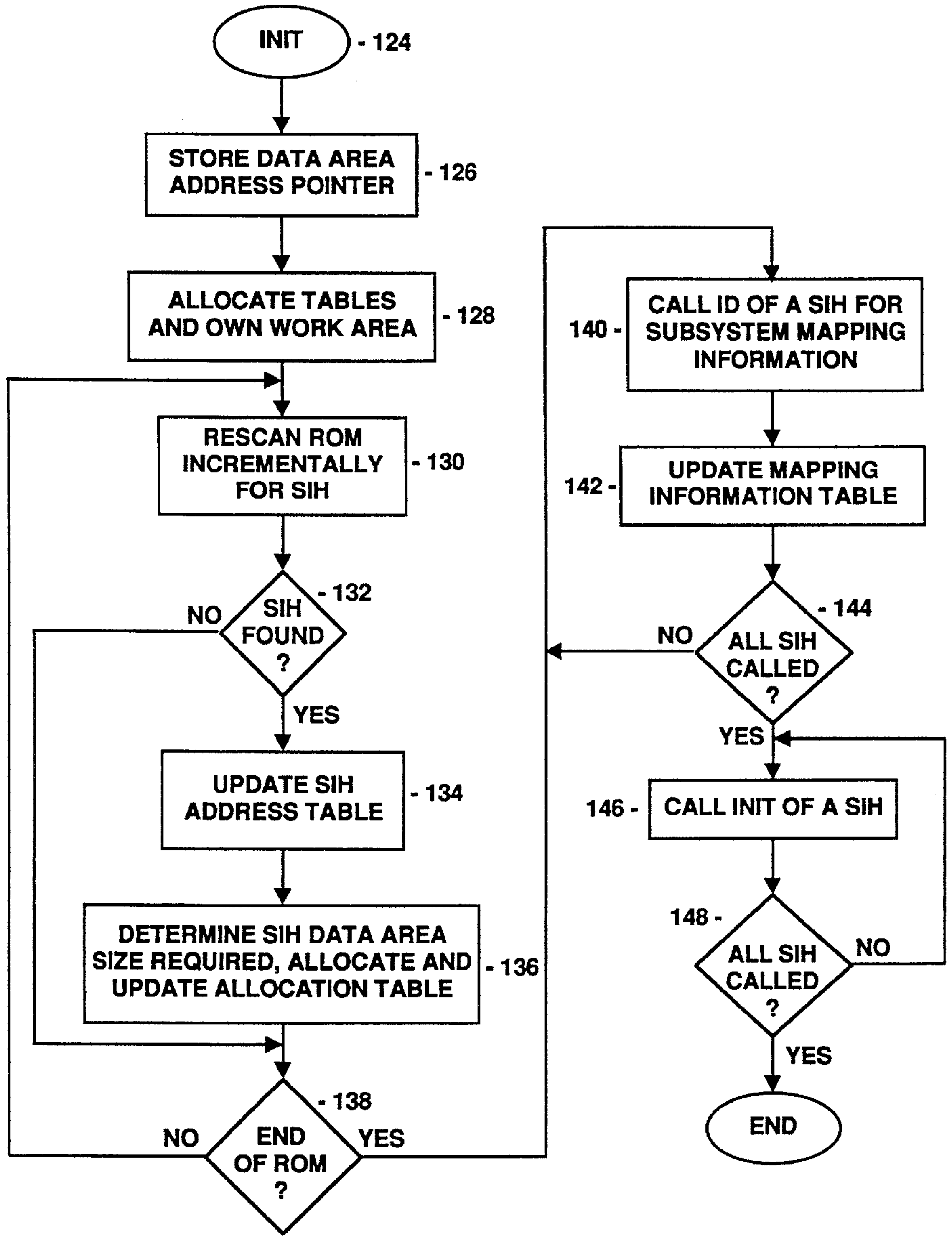

INIT
124
STORE DATA AREA ADDRESS POINTER
126
ALLOCATE TABLES AND OWN WORK AREA
128
RESCAN ROM INCREMENTALLY FOR SIH
130
SIH FOUND ?
132
NO
YES
UPDATE SIH ADDRESS TABLE
134
DETERMINE SIH DATA AREA SIZE REQUIRED, ALLOCATE AND UPDATE ALLOCATION TABLE
136
END OF ROM ?
138
NO
YES
CALL ID OF A SIH FOR SUBSYSTEM MAPPING INFORMATION
140
UPDATE MAPPING INFORMATION TABLE
142
ALL SIH CALLED ?
144
NO
YES
CALL INIT OF A SIH
146
ALL SIH CALLED ?
148
NO
YES
END

Figure 7

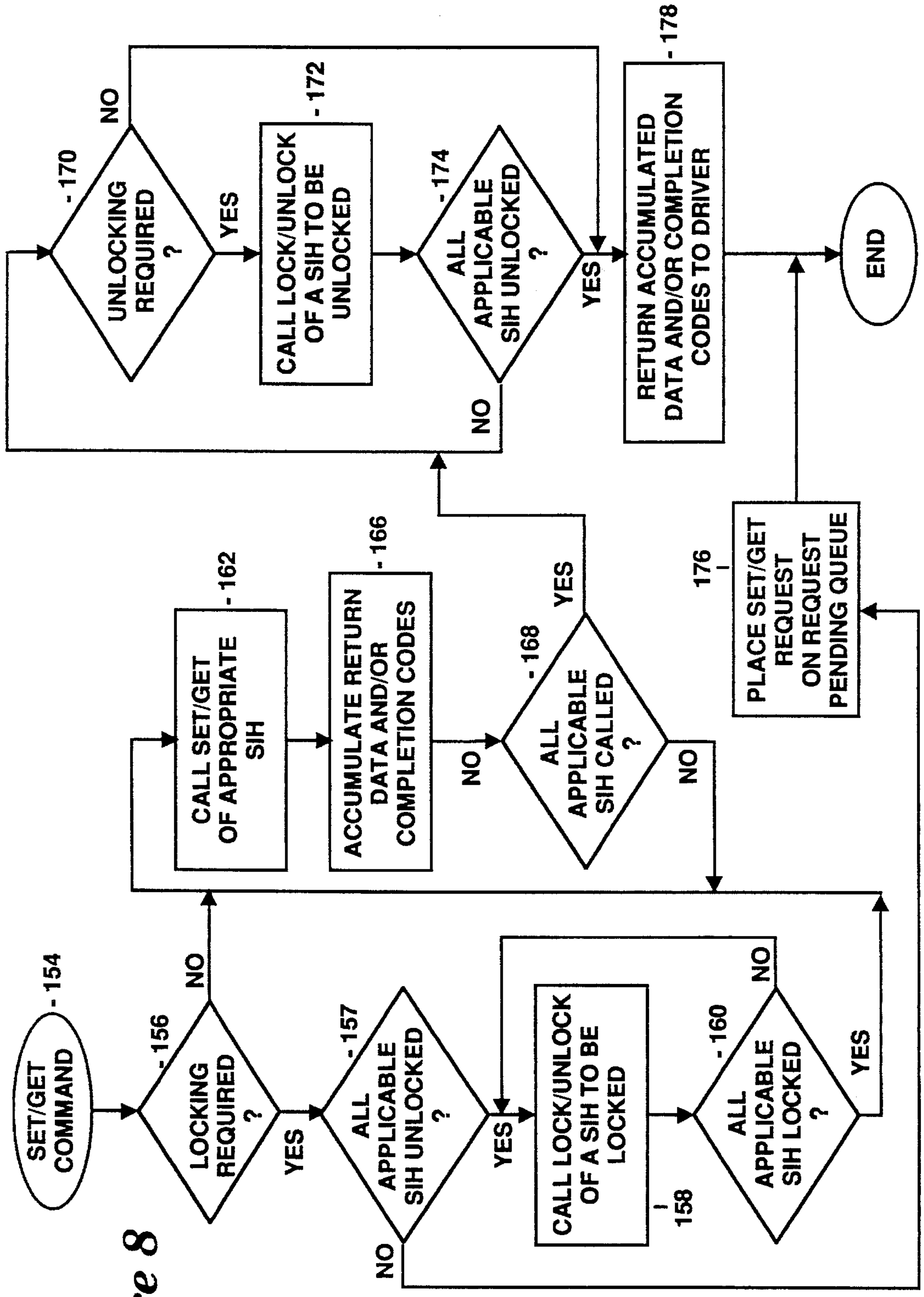

SET/GET COMMAND
154
LOCKING REQUIRED ?
156
NO
YES
ALL APPLICABLE SIH UNLOCKED ?
157
YES
NO
CALL LOCK/UNLOCK OF A SIH TO BE LOCKED
158
ALL APPLICABLE SIH LOCKED ?
160
NO
YES
CALL SET/GET OF APPROPRIATE SIH
162
ACCUMULATE RETURN DATA AND/OR COMPLETION CODES
166
ALL APPLICABLE SIH CALLED ?
168
NO
YES
NO
PLACE SET/GET REQUEST ON REQUEST PENDING QUEUE
176
UNLOCKING REQUIRED ?
170
YES
NO
CALL LOCK/UNLOCK OF A SIH TO BE UNLOCKED
172
ALL APPLICABLE SIH UNLOCKED ?
174
YES
NO
RETURN ACCUMULATED DATA AND/OR COMPLETION CODES TO DRIVER
178
END

Figure 8

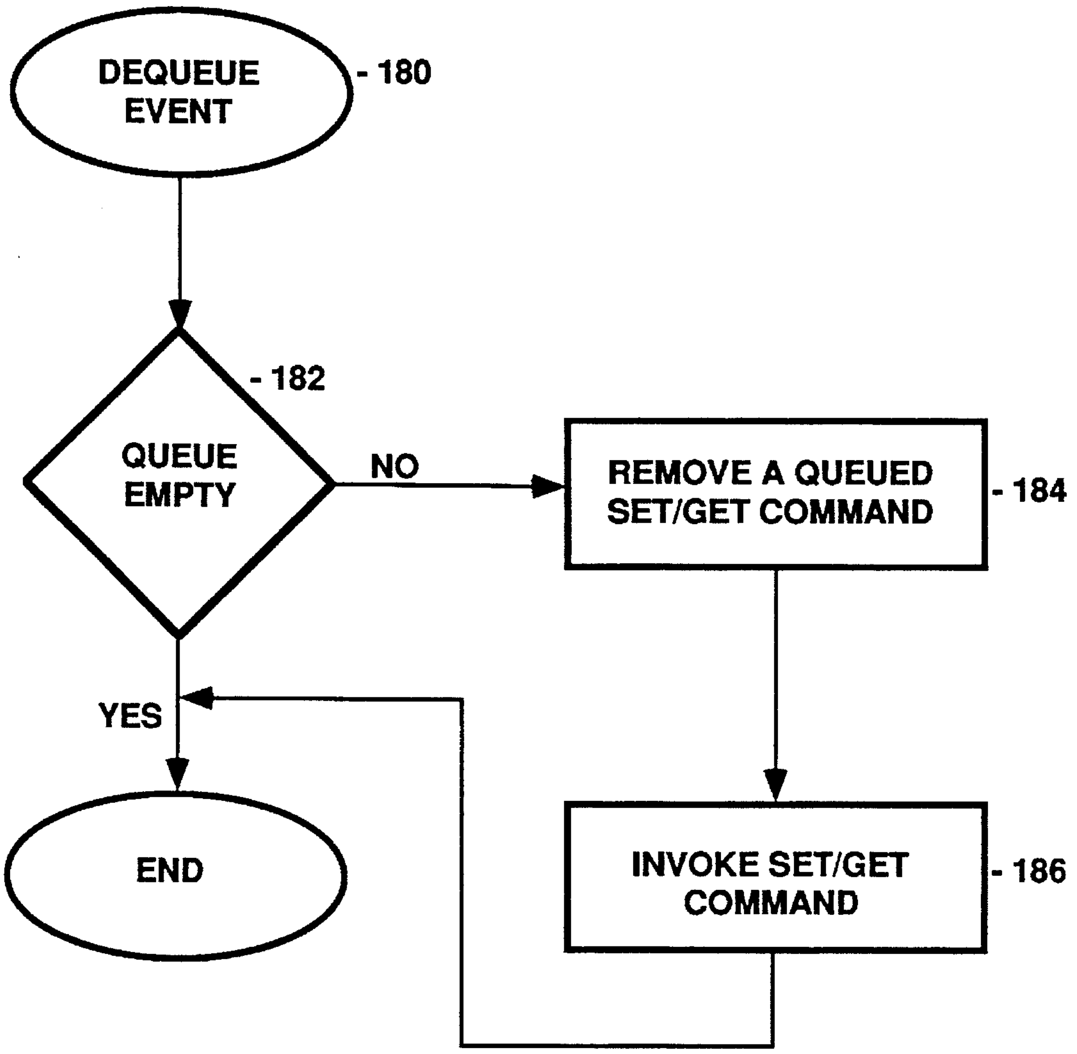

DEQUEUE EVENT
180
QUEUE EMPTY
182
NO
REMOVE A QUEUED SET/GET COMMAND
184
YES
END
INVOKE SET/GET COMMAND
186

Figure 9

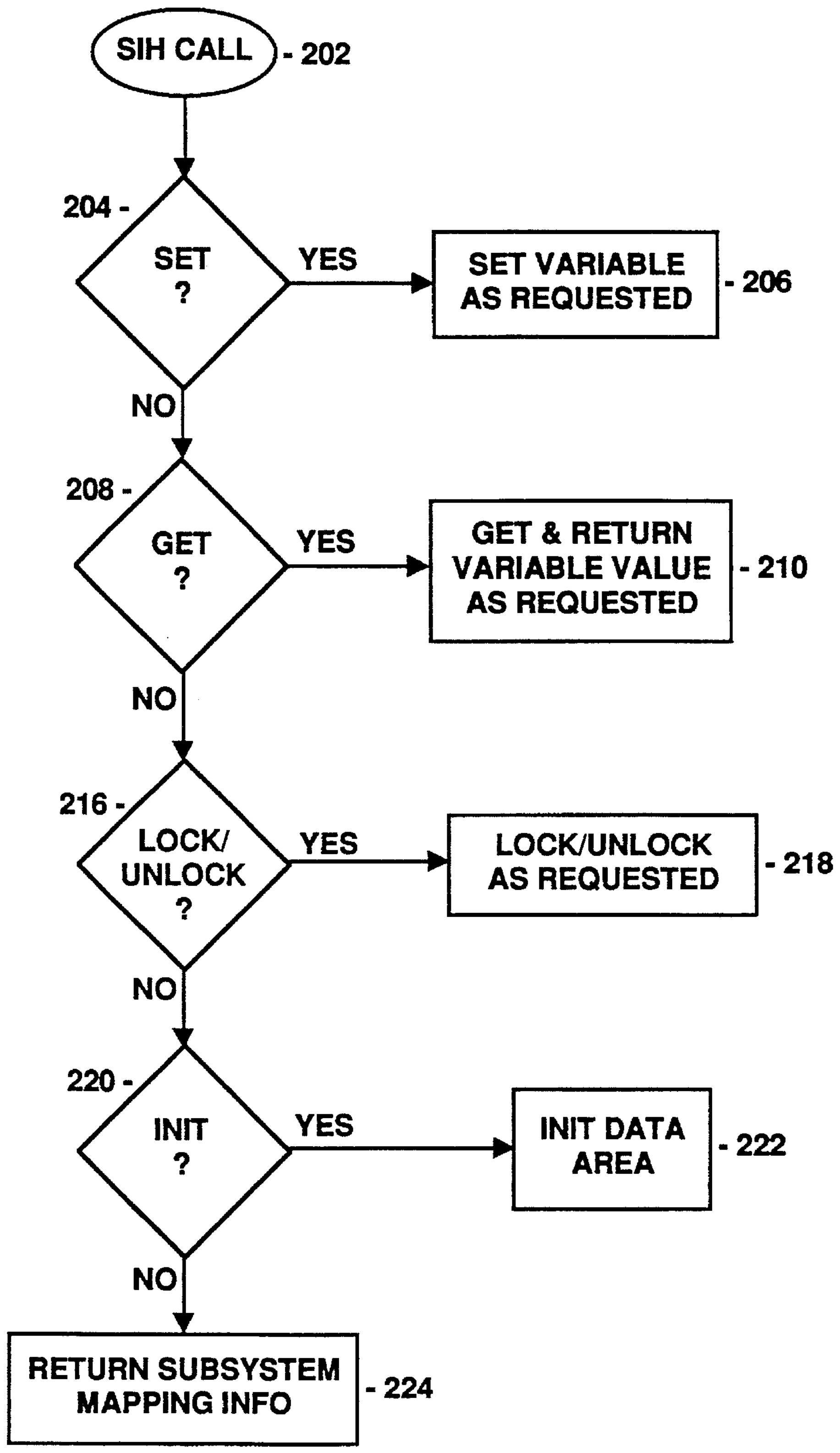

SIH CALL
202
204
SET ?
YES
SET VARIABLE AS REQUESTED
206
NO
208
GET ?
YES
GET & RETURN VARIABLE VALUE AS REQUESTED
210
NO
216
LOCK/ UNLOCK ?
YES
LOCK/UNLOCK AS REQUESTED
218
NO
220
INIT ?
YES
INIT DATA AREA
222
NO
RETURN SUBSYSTEM MAPPING INFO
224

Figure 10

METHOD AND APPARATUS FOR ACCESSING SYSTEM MANAGEMENT FUNCTIONS OF A COMPUTER SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to the field of computer systems. More specifically, the present invention relates to accessing system management features and functions of these computer systems.

2. Background Information

For operations in today's complex computing environments, it is becoming essential for modern computer systems to be equipped with features and functions that allow them to be easily managed, both in stand-alone as well as networked environments. Examples of system management features and functions include fault management, performance management, configuration management, security management, and accounting management features and functions.

Typically, the system management features and functions of a computer system are accessed through subsystem instrumentation software executing on the computer system. Examples of subsystems are CPU, memory, disk storage. The subsystem instrumentation software are selectively invoked by local management agent software, in response to system management requests from management console software, which interacts with a system manager. The system manager and the management console software may be local or remotely located from the management agent software and the instrumentation software.

Conventionally, a subsystem instrumentation software module is made up of three major code segments, a first segment that is operating system specific for interfacing with the management agent software, a second segment that is platform specific for accessing the management features and functions of the subsystem, and a third segment that bridges the first and second segments. For the purpose of this disclosure, the term platform refers to a vendor specific hardware and enabling software combination, where the enabling software are hardware specific and operating system independent. An example of enabling software is system BIOS.

Since each platform contains multiple subsystems, and each subsystem may have multiple implementations, a platform vendor provides a subsystem instrumentation software module for each operating system, subsystem implementation, and subsystem combination. As can be appreciated, the effort required of a platform vendor to facilitate accesses to system management features and functions under such conventional approach can quickly become untenable.

Thus, it is desirable to be able to facilitate accesses to system management features and functions in a more efficient and cost effective manner. As will be disclosed in more detail below, the present invention provides for a method and apparatus that achieves these and other desirable results.

SUMMARY OF THE INVENTION

These and other desirable results are advantageously achieved by providing a number of system instrumentation drivers (SID), a subsystem instrumentation interface (SII), and a number of subsystem instrumentation handlers (SIHs), for accessing system management features and functions of a platform. The SID are operating system specific; they are used to issue subsystem commands to the SII, in response to system management calls from system management agent software. The SII is platform, operating system as well as subsystem implementation independent; it is used to map subsystem commands into invocations of the appropriate SIHs. The SIHs are platform and subsystem specific; they are used to access the various system management features and functions of the platform.

The SII includes a number of functions, including a Set function for invoking the appropriate SIHs to set the variables of the various subsystems, and a Get function for invoking the appropriate SIHs to get the current values of the subsystem variables. Correspondingly, each SIH include a number of services, including a Set service for setting the variables of at least one subsystem, and a Get service for getting the current values of the variables of at least one subsystem.

The SII further includes an interface data area for storing a number of dynamically constructed tables and a number of dynamically allocated working data areas. The tables include a memory allocation table of the memory locations of the allocated working data areas, an address table of the memory locations of the SIHs, and a mapping table of subsystem to SIH entries. The working data areas include the working data areas of the SII functions and the working data areas of the SIHs.

Additionally, in certain embodiments, a SIH may serve multiple subsystems, and one subsystem may be serviced by multiple SIHs, with the SII providing the necessary tracking of the relationships between subsystems and SIHs, and supporting atomic operations against those subsystems requiring services of multiple SIHs. In these embodiments, the SII Set and Get functions are further equipped to invoke the appropriate SIHs to lock and unlock themselves before and after the invocations of their Set and Get services. The services provided by each SIH further include a lock/unlock service for locking and unlocking itself.

In certain variations of these embodiments, the allocated working data areas further include a queue for queuing Set and Get commands from the SID that cannot be processed due to the required SIHs being locked. The SII Set and Get functions are further equipped to placing these Set and Get commands from the SID onto the queue. The SII functions further include a dequeue function for dequeuing these pending Set and Get commands for retries, responsive to dequeuing events.

Furthermore, in certain embodiments, the SII functions further include a Discover function for locating the SIHs present and learning about their working area size requirements, and an initialize function for initializing the interface data area. In certain variations of these embodiments, each SIH further includes a header having a predetermined SIH identifier, the SIH's name, the SIH's size, the SIH's checksum, and the SIH's data area size. The SIH services include an identify service for identifying the subsystem(s) it services, and an initialize service for initializing itself.

BRIEF DESCRIPTION OF DRAWINGS

FIGS. **1** illustrates an exemplary computer system incorporating the teachings of the present invention.

FIG. **2** illustrates the system management features and functions access architecture of the present invention.

FIG. **3** is an exemplary subsystem definition including exemplary subsystem variables.

FIG. **4** illustrates one embodiment of the SII in further detail.

FIGS. **5***a*–**5***c* illustrates one embodiment of a SIH, including its data area, in further detail.

FIGS. **6**–**9** are flow diagrams of the Discover, Initialize, Set, Get, and Dequeue functions of one embodiment of the SII.

FIG. **10** is a flow diagram of one embodiment of a SIH.

DETAILED DESCRIPTION

In the following description, for purposes of explanation, specific numbers, materials and configurations are set forth in order to provide a thorough understanding of the present invention. However, it will be apparent to one skilled in the art that the present invention may be practiced without the specific details. In other instances, well known systems are shown in diagrammatic or block diagram form in order not to obscure the present invention.

Referring now to FIG. **1**, a diagram illustrating an exemplary computer system incorporating the teachings of the present invention is shown. The exemplary computer system **10** comprises a processor **12**, a read only memory **14**, a cache memory **16**, a main memory **20**, and memory controller **18**, coupled to each other and a processor bus **28** as shown. The exemplary computer system **10** further comprises an I/O controller **22**, a number of mass storage devices **24**, and a number of communication interfaces **26**, coupled to each other and an I/O bus **30** as shown. The memory and I/O controllers **18** and **22** are also coupled to each other.

The various elements **12**–**30** are provided with an assortment of system management features and functions. For examples, some of the communication interfaces are equipped to report for fault features such as the number of errors detected for a fault logging function; the cache memory **16** is equipped to report for performance features such as the cache hit rate since the beginning of a sampling period for a performance sampling function; the main memory **20** is equipped to identify for configuration features such as its size for a system configuration function; the keyboard interface (not shown) to which the keyboard and cursor control devices **27** are connected is equipped to report for security features such as the number of failed login attempts since last query for a keyboard security function; and the mass storage interface (not shown) to which the mass storage devices **24** are connected is equipped to report for accounting features such as usage statistics for a disk space allocation function.

As a further example, a video add-on card (not shown) is equipped to allow setting of configuration features such as video display type of a system configuration function, which in turn controls the embedded software video driver that get executed, thereby altering the behavior of the system.

Additionally, the exemplary computer system **10** is equipped with access software for accessing these system management features and functions, in accordance to the teachings of the present invention, and system management agent software that utilizes these access software to access the system management features and functions. These access software and the manner in which they cooperate with each other and the system management agent software will be described in detail below.

Except for the system management features and functions incorporated, and the manner in which they are utilized by the access software and the system management agent software, these elements **12**–**30** are intended to represent a broad category of similar elements found in many computer systems. Their primary functions and constitutions are well known and will not be further described. Furthermore, based on the descriptions to follow, it will be appreciated that the present invention may be practiced with these elements **12**–**30** coupled to each other in other architectural manner, without some of these elements **12**–**30**, and with other additional hardware elements.

Referring now to FIG. **2**, a block diagram illustrating the system management features and functions access architecture of the present invention is shown. As illustrated, the system management agent software **34**, in response to user system management requests from local/remote system management console software interfacing with a system manager, makes various system management calls to the system instrumentation driver (SID) **36** of the access software **32**. In due course, upon receiving the requested data or completion codes from the SID **36**, the system management agent software **34** replies to the system management requests.

In addition to the SID **36**, the system management features and functions access software **32** further includes a subsystem instrumentation interface (SII) **38**, and a number of subsystem instrumentation handlers (SIHs) **40**. The SID **36** is operating system specific; it is used to issue subsystem commands to the SII **38**, in response to system management calls from the system management agent software **34**. The SII **38** is platform, operating system as well as subsystem implementation independent; it is used to map each subsystem command into one or more invocations of the appropriate SIHs **40**. As will be described in more detail below, the SII **38** includes a number of functions and an interface data area (**50** and **62** of FIG. **4**). The SIHs **40** are platform and subsystem specific; they are used to make the appropriate accesses to the various system management features and functions of the platform.

In one embodiment, the SIHs **40** are further equipped to notify the SII **38** of certain subsystem events. The SII **38** in turn percolates these event notifications to the SID **36**. The SID **36** then forwards these event notifications to those system management agents **34** who have previously informed the SID **36** of their interest in such events (e.g. through a registration process implemented in any one of a number of well known manners). In the context of the present invention, these event notifications can be considered as “unsolicited responses” from the SIHs **40**, which are handled in the same manner as the “solicited” responses from the SIHs **40** to be described in more detail below.

Each SIH **40** may support one or more subsystem, and likewise, each subsystem may be serviced by one or more SIH **40**. In addition, while in general the SIHs **40** access the subsystem hardware directly, for certain protected subsystem hardware, the SIHs **40** access the protected subsystem hardware through secured access services provided by the operating system.

In one embodiment, the SID **36** is stored in one of the mass storage devices **24**, and loaded into the main memory **20** for execution by the operating system (not shown) during system initialization. The functions **50** of the SII **38** are stored and executed in place in the read only memory **14**, whereas the interlace data area **62** of the SII **38** is located in a memory segment of the main memory **20** allocated by the operating system during system initialization. The SIHs **40** are also stored and executed in place in the read only memory **14**.

In an alternate embodiment, the functions **50** of the SII **38** are also stored in one of the mass storage devices **24**, and loaded into the main memory **20** for execution by the operating system (not shown) during system initialization.

In yet another alternate embodiment, the SIHs are also stored in one of the mass storage devices **24**, and loaded into the main memory **20** for execution by the operating system (not shown) during system initialization.

The SID **36** may be implemented in like manners as the operating system specific portions of conventional subsystem instrumentation modules. Thus, except for the manner in which the SID **36** cooperates with the SII **38**, it will not be further described. The SII **38**, and the SIHs **40** will be described in more detail below.

Referring now to FIG. **3**, a block diagram illustrating an exemplary subsystem definition including exemplary subsystem variables is shown. The subsystems **43**, for examples, "CPU/Cache Subsystem", "Main Memory Subsystem", and their variables **44**, for examples, "Number of CPU", "CPU Type" are enumerated. Additionally, each subsystem **43** is assigned an integer subsystem identifier **45**, for examples, "1" for "CPU/Cache Subsystem", "2" for "Main Memory Subsystem", and each subsystem variable is also assigned an integer variable identifier **46**, for examples, "1" for "Number of CPU", "2" for "CPU Type". Thus, each variable **44** of each subsystem **43** can be identified by a pair of integers {S:V}.

The subsystem and vadable definition is expected to be specific for a range of computer system products from a given manufacturer. In other words, assuming the exemplary definition **42** applies to computer product line Y of Company X, for all models of computer product line Y manufactured by Company X, the "CPU/Cache Subsystem" would always be "addressable" with the subsystem ID "1". Furthermore, the subsystem variable "CPU Type" would always be accessible as variable ID "2" (i.e. an {S:V} integer pair of "1:2").

Referring now to FIG. **4**, a block diagram illustrating the SII of the present invention in further detail is shown. The SII **38** includes a number of functions **50**. The functions **50** includes a Set function **56** for invoking the appropriate SIHs **40** to set the variables of the various subsystems, and a Get function **52** for invoking the appropriate SIHs **40** to retrieve the values of the variables of the vadous subsystems. The SII **38** also includes an interface data area **62**. The interface data area **62** stores a number of dynamically constructed tables **64–68**, and a number of dynamically allocated working data areas **70**. The tables **64–68** include a memory allocation table **64** of the memory locations of the allocated working data areas **70**, an address table **68** of the memory locations of the SIHs **40**, and a mapping table **66** of subsystem to SIH entries. The working data areas **70** include working data areas of the SII functions **50** and working data areas of the SIHs **40**.

The Set and Get functions **56** and **58** are used during operation by the SID **36** to access the system management features and functions of the platform. The SID **36** selectively invokes the Set and Get functions **56** and **58** specifying an {S:V}integer pair denoting the subsystem and the subsystem management feature/function variable to be operated on. In response, upon causing the requested operation to be performed, the Set and Get functions **56** and **58** returns the data or completion codes.

Additionally, for embodiments where a SIH **40** may serve multiple subsystems, the Set and Get functions **56** and **58** are further equipped to invoke the appropriate SIHs **40** to lock and unlock themselves before and after the invoking them for setting subsystem variables and getting subsystem variable values. In certain variations of these embodiments, the allocated working data areas **70** further include a queue for queuing Set and Get commands from the SID **36** that cannot be processed due to the required SIHs **40** being locked. The Set and Get functions **56** and **58** are further equipped to placing these Set and Get commands from the SID onto the queue. The SII functions **50** further include a dequeue function **59** for dequeuing these pending Set and Get commands fro retries, responsive to dequeuing events, which will be described in more detail below.

Furthermore, in certain embodiments, the SII functions **50** further include a Discover function **52** for locating the SIHs **40** present and learning about their working data area size requirements, and an Initialize function **54** for initializing the interface data area **62**, including allocation and creation of the tables **64–68**, and allocation of the working data areas **70**.

The Discover function **52** is called by the SID **36** at pre-initialization time, also referred to as discovery time, during system start up. The Discover function **52** returns its interface data area size requirement to the SID **36**, which in turn causes the required memory area to be allocated (through the operating system). The Initialize function **54** is called by the SID **36** at initialization time. At invocation, the SID **36** provides an address pointer **60** to the allocated interface data area **62** to the Initialize function **54**. In response, upon successful initialization, the Initialize function **54** notifies the SID **36** accordingly.

Lastly, for some embodiments, the address pointer **60** to the starting location of the interface data area **62** is stored in a predetermined location of the computer system **10**. The various tables **64–68** may be implemented in a number of well known manners, which are well within the ability of those skilled in the art, and therefore will not be further described. The SII functions **50** will be described in more details below.

Referring now to FIGS. **5*a*–5*c***, three block diagrams illustrating a SIH, including its services, its working data area, and its header, are shown. As illustrated in FIG. **5*a***, a SIH **40** includes a number of services. The SIH services include a Set service **78** for setting the variables of at least one subsystem, and a Get service **80** for getting the current values of the variables of at least one subsystem. As illustrated in FIG. **5*b***, each SIH **40** has a corresponding working data area **70** for storing the working data **94** of the SIH **40**. As briefly described earlier and will be described in more detail below, the Set and Get services **78** and **80** are invoked by the SII **38** during operation, and the working data area **70** is allocated in the interface working data area **62** of the SII **38**.

Additionally, for some embodiments, as illustrated in FIG. **5*a***, the SIH services further include an Identify service **74** for identifying the subsystem(s) supported by the SIH **40**. The Identify service **74** is invoked by the SII **38** at initialization time. For embodiments where a SIH **40** may support multiple subsystems and the SII Set and Get functions **56** and **58** support atomic operations, as illustrated in FIG. **5*b***, the working data area **70** of a SIH **40** further includes a lock/unlock semaphore **92**. As illustrated in FIG. **5*a***. the SIH services further include a lock/unlock service **82** for setting and resetting the lock/unlock semaphore **92**.

Furthermore, for certain embodiments, as illustrated in FIG. **5*a***, the SIH services further include an Initialize service **74** for initializing the working data area **70** of the SIH at initialization time, and a header **72** containing identification and data area size requirement information to allow the SIH's presence to be discovered at pre-initialization time and its working data area size requirement be accounted for at initialization. As illustrated in FIG. 5*c*, a SIH header **72** includes a predetermined SIH identifier **84** marking the beginning of the SIH **40**, a SIH name **85** identifying the SIH **40**, the SIH's size **86** identifying its object code size, the SIH's object code checksum value **88**, and the SIH's working data area size requirement **90**. As will be described in more detail below, these information **84–90** stored in the SIH header **72** are read by the SII **38** to detect and determine the SIH's presence at pre-initialization or discovery time.

Referring now to FIGS. **6–9**, four flow diagrams illustrating the operation flow of one embodiment each of the Discover, Initialize, Set/Get and Dequeue functions of the SII are shown. The Set/Get functions **56** and **58** will be described first with embodiments that operate in like manners and support atomic operations against subsystems serviced by multiple SIHs **40**, referencing FIG. **8**. The Dequeue function **59** will then be described, referencing FIG. **9**, followed by the Discover and Initialize functions **52** and **54**, referencing FIGS. **6** and **7** respectively.

Skipping now to FIG. **8**, as illustrated, upon invocation, the Set/Get function **56** or **58** determines if locking is required by accessing the mapping table **66** to see if the subsystem is serviced by multiple SIHs **40**, step **156**. If locking is required, the Set/Get function **56** or **58** further determines if all required SIHs **40** are unlocked by accessing the lock/unlock semaphores **92** of the required SIHs **40**, step **157**. If at least one of the required SIHs **40** is locked, the Set/Get function **56** or **58** places the invoking Set/Get Command on the pending command queue, step **176**.

However, if all required SIHs **40** are unlocked at step **157**, the Set/Get function **56** or **58** calls the lock/unlock services **82** of all applicable SIHs **40** to lock themselves, steps **158** and **160**.

If no locking is required at step **156**, or upon successful locking of all applicable SIHs **40** at step **160**, the Set/Get function **56** or **58** calls the corresponding Set/Get services **78** or **80** of the appropriate SIHs, steps **162–168**. The return data and/or completion code(s) are accumulated, step **166**. The Set/Get function **56** or **58** calls the corresponding Set/Get services **78** or **80** of the appropriate SIHs at steps **162–168** in like manner, using a {S:V} integer pair denoting the subsystem and the subsystem management features/functions variable to be operated on.

Upon completing making one or more calls to the corresponding Set/Get services **78** or **80** of one or more SIHs **40**, if locking was previously performed, step **170**, the Set/Get function **56** or **58** calls the lock/unlock services **82** of all appropriate SIHs **40** again to unlock themselves, steps **172** and **174**.

If no unlocking is required at step **170**, or upon unlocking all applicable SIHs **40** at step **174**, the Set/Get function **56** or **58** returns the accumulated data and/or completion code(s) to the invoking SID **36**, step **178**.

Referring now to FIG. **9**, as illustrated, upon detection of a dequeue event, the Dequeue function **59** determines if the pending command queue is empty, step **182**. A dequeue event may include the expiration of a predetermined time interval since the last time the pending command queue was checked, and/or the completion of a Set/Get command. If the pending command queue is empty at step **182**, no further action is taken. On the other hand, the pending command queue is not empty, a queued Set/Get command **184** is removed for retry, step **184**, and the Set/Get function **56** or **58** is invoked as if the SID **36** is invoking the function, step **186**. The queued Set/Get command may be removed from the pending command queue **184** in a first-in-first-out basis or with any one of a number of well known pdority basis.

Referring back to FIG. **6**, upon invocation, the Discover function **52** scans a predetermined sequential extent of the read only memory **14** for the predetermined SIH identifier **84**, step **104**. The size of the predetermined sequential extent is a function of the size of the SIH identifier **84** used. If the memory extent does not contain the predetermined SIH identifier **84** and the end of the read only memory **14** has not been reached, steps **106** and **108**, the Discover function **52** continues at step **104**.

Whenever the predetermined SIH identifier is "detected" at step **106**, the Discover function **52** scans another predetermined sequential extent of the read only memory **14** for the "SIH name" **85**, the "SIH size" **86**, the "SIH's checksum" **88**, and the "SIH's data area size requirement" **90**, step **112**. Then the Discover function **52** checksums a sequential extent of the read only memory **14** based on the "SIH size" **86** read. If the checksum does not match, step **116**, the Discover function **52** backtracks to where the false "SIH identifier" was found, step **118**. If the false "SIH identifier" is not at the end of the read only memory **14**, step **108**, the Discover function **52** continues at step **104** again.

However, if the checksum matches at step **116**, a SIH **40** indeed has been detected. Then, the Discover function **52** accumulates the SIH's data area size requirement **90**, step **120**. Again, if the end of the read only memory **14** has not been reached, step **108**, the Discover function **52** continues at step **104**.

Eventually, when the end of the read only memory **14** is reached at step **108**, the Discover function **52** estimates the total interface data area size requirement based the accumulated data area size requirements of the SIHs **40** present, its own table and working data area requirements, and returns the total requirement to the invoking SID **36**, step **110**.

Referring now to FIG. **7**, upon invocation, the Initialize function **54**, in one embodiment, stores the address pointer **60** to the allocated interface data area at a predetermined location of the computer system **10**, step **126**. The address pointer **60** is stored in the predetermined location for future usage by the SIHs **40** to access their working data areas **70**. Alternative arrangements may be made. Upon storing the address pointer **60**, the Initialize function **54** allocates portions of the interface data area **62** for its tables **64–68**, and its own working data area **70**, step **128**. The memory allocation table **64** is allocated at a predetermined offset into the interface data area **62** to facilitate accesses by the SIHs **40**. Similarly, alternative arrangements may be made.

Next, the Initialize function **54** scans the read only memory **14** incrementally for SIHs **40**, similar to the manner in which the Discover function **52** scan for SIHs **40**, step **130**. If a SIH **40** is not found and the end of the read only memory **14** has not been reached, steps **132** and **138**, the Initialize function **54** continues at step **130** again. However, if a SIH **40** is found at step **132**, the Initialize function **54** updates the address table **68** to keep track of the SIH's location, step **134**. The Initialize function **54** further determines the SIH's data area size requirement, allocates a portion of its interface data area **62**, and updates the memory allocation table **64** accordingly, step **136**. Again, if the end of the read only memory **14** has not been reached, step **138**, the Initialize function **54** continues at step **130**.

Upon reaching the end of the read only memory **14**, step **138**, in other words, having found all the SIHs **40** present again and kept track of their locations, the Initialize function **54** calls the Identify service **74** of a SIH **40** to request identification of the subsystems it supports, step **140**. The Initialize function **54** then updates the mapping table **66** accordingly based on the response from the identify service **74** of the SIH **40** called, step **142**. The Initialize function **54** repeats steps **140** and **142**, until all SIHs **40** present have been called and identified the subsystems they support.

After all SIHs **40** present have identified their support, the Initialize function **54** then calls the Initialize services **76** of the SIHs **40** to initialize themselves, steps **146** and **148**. In one embodiment, each of SIHs **40** locates its working area by accessing the address pointer **60** to the starting location of the interface data area **62** at the predetermined location, and the offset to its working area **70** from the memory allocation table **64**. The initialization performed by each of the SIHs **40** is SIH dependent.

Having now described the operation flows of the vadous functions of the SII **38**, before the operation flow of an exemplary SIH **40** is described, it should be noted that the detection and learning of the SIHs **40** as well as the initialization of the SII **38** and SIHs **40** may be performed in a variety of equivalent manners.

Referring now to FIG. **10**, a flow diagram illustrating the operation flow of an exemplary SIH is shown. In this embodiment, as illustrated, upon invocation, the SIH **40** determines whether it is its Set service **78** that is being invoked, step **204**. If it is the Set service **78** that is being invoked, the SIH **40** sets the variable as requested, step **216**. If it is not the Set service **78** that is being invoked at step **204**, the SIH **40** then determines whether it is its Get service **80** that is being invoked, step **208**. If it is the Get service **78** that is being invoked at step **208**, the SIH **40** gets the current value of the variable as requested, step **210**.

Similarly, if at step **208**, the SIH **40** is not being invoked for its Get service **80**, the SIH **40** further determines whether it is its Lock/Unlock service **82** that is being invoked, step **216**. If it is its the Lock/Unlock service **82** that is being invoked at step **216**, the SIH **40** performs the locking or unlocking operation as requested, step **218**. If at step **216**, the SIH **40** is not being invoked for its Lock/Unlock service **82**, the SIH **40** further determines whether it is its Initialize service **76** is being invoked, step **220**. If it is its Initialize service **76** that is being invoked, the SIH **40** performs the initialization as requested, step **222**.

Lastly, if at step **220**, the SIH **40** is not being invoked for its Initialize service **76**, the SIH **40** is being invoked for its Identify service **74**. The SIH **40** then performs the identification service as requested, step **224**.

Thus, a novel method and apparatus for accessing system management functions and features has been described. While the present invention has been described in terms of the illustrated embodiments, those skilled in the art will recognize that the invention is not limited to the embodiments described. The method and apparatus of the present invention can be practiced with modification and alteration within the spirit and scope of the appended claims. The description is thus to be regarded as illustrative instead of restrictive on the present invention.

I claim:

1. In a computer system having system management information, a method for manipulating or retrieving said system management information by a system management agent, said method comprising the steps of:

a) said system management agent causing subsystem set or get commands to be issued to a subsystem instru-

mentation interface, said set or get commands including subsystem and subsystem variable identifications, said set commands further including set values for said identified subsystem variables of said identified subsystems;

b) said subsystem instrumentation interface in response invoking set or get services of subsystem instrumentation handlers, and providing said invoked set or get services of said subsystem instrumentation handlers with said subsystem and subsystem variable identifications, and for set services, said set values; and

c) said subsystem instrumentation handlers in response setting said identified subsystem variables of said identified subsystems to said set values or getting current values of said identified subsystem variables of said identified subsystems.

2. The method as set forth in claim **1**, wherein said method further comprises the steps of:

d) said subsystem instrumentation handlers returning completion codes to said subsystem instrumentation interface;

e) said subsystem instrumentation interface causing said completion codes to be returned to said system management agent.

3. The method as set forth in claim **1**, wherein said method further comprises the steps of:

d) said subsystem instrumentation handlers returning said current values to said subsystem instrumentation interface;

e) said subsystem instrumentation interface causing said current values to be returned to said system management agent.

4. The method as set forth in claim **1**, wherein said method further comprises the steps of:

d) said subsystem instrumentation handlers notifying said subsystem instrumentation interface of system events;

e) said subsystem instrumentation interface causing said system event notifications to be selectively forwarded to said system management agent.

5. The method as set forth in claim **1**, wherein,

said method further comprises the step of d) said subsystem instrumentation interface invoking locking/unlocking services of said subsystem instrumentation handlers to lock/unlock said subsystem instrumentation handlers for achieving atomic results for subsystems supported by multiple subsystem instrumentation handlers,

said step (d)is performed before said step (b) is performed for any subsystem instrumentation handler, and after said step (c) has been performed by all subsystem instrumentation handlers.

6. The method as set forth in claim **5**, wherein said step (d) further comprises said subsystem instrumentation interface checking said subsystem instrumentation handlers to determine if they are locked prior to invoking their locking services.

7. The method as set forth in claim **6**, wherein,

said method further comprises the step of e) said subsystem instrumentation interface logging said set or get commands for subsequent retries,

said step (e) being performed in lieu of said steps (b) and (c) whenever at least one subsystem instrumentation handler is locked while performing said step (d) for a set or get command.

8. The method as set forth in claim **7**, wherein,

said step e) comprises placing said set or get commands on a pending command queue;

said method further comprises the step of f) said subsystem instrumentation interface dequeuing said set or get commands for retry in response to detections of dequeuing events.

9. The method as set forth in claim **8**, wherein said dequeuing events include i) expiration of a predetermined time interval since said pending command queue was last checked, and ii) completion of a set or get command.

10. The method as set forth in claim **1**, wherein said method further comprises the steps of:

d) said subsystem instrumentation interface being commanded to initialize said subsystem instrumentation interface and cause said subsystem instrumentation handlers to be initialized;

e) said subsystem instrumentation interface in response dynamically detects how many subsystem instrumentation handlers are present, and determines memory locations of said subsystem instrumentation handlers;

said subsystem instrumentation interface further determines subsystem coverage of said subsystem instrumentation handlers, allocates subsets of a working area of said subsystem instrumentation interface as working areas of said subsystem instrumentation handlers, and invoking initializing services of said subsystem instrumentation handlers; and

f) said system instrumentation handlers in response initialize themselves.

11. The method as set forth in claim **10**, wherein said steps (d) through (f) are performed at initialization time after said subsystem instrumentation interface has been allocated said working area of said subsystem instrumentation interface, but before any of said steps (a) through (c) are performed.

12. The method as set forth in claim **1**, wherein said method further comprises the steps of:

d) said subsystem instrumentation interface being commanded to provide an estimate of a working area size requirement for said subsystem instrumentation interface;

e) said subsystem instrumentation interface in response dynamically determines how many subsystem instrumentation handlers are present, and what the subsystem instrumentation handlers' working area size requirements are;

f) said subsystem instrumentation interface then estimates a total working area size requirement for the subsystem instrumentation interface, and provides said total working area size requirement; and

g) said subsystem instrumentation interface being allocated a working area having said total working area size required.

13. The method as set forth in claim **12**, wherein said steps (d) through (g) are performed at preinitialization time before any of said steps (a) through (c) as well as initialization are performed.

14. The method as set forth in claim **1**, wherein said step (a) comprises the steps of:

a.1) said system management agent requesting a system instrumentation driver to manipulate or retrieve said system management information; and

a.2) said system instrumentation driver in response issuing said subsystem set or get commands to said subsystem instrumentation interface.

15. The method as set forth in claim **14**, wherein said method further comprises the steps of:

d) said subsystem instrumentation handlers returning completion codes to said subsystem instrumentation interface;

e) said subsystem instrumentation interface returning said completion codes to said system instrumentation driver; and

f) said system instrumentation driver returning said completion codes to said system management agent.

16. The method as set forth in claim **14**, wherein said method further comprises the steps of:

d) said subsystem instrumentation handlers returning said current values to said subsystem instrumentation interface;

e) said subsystem instrumentation interface returning said current values to said system instrumentation driver; and

f) said system instrumentation driver returning said current values to said system management agent.

17. The method as set forth in claim **14**, wherein, said method further comprises the steps of:

d) said subsystem instrumentation handlers notifying said subsystem instrumentation interface of system events;

e) said subsystem instrumentation interface forwarding said system event notifications to said system instrumentation driver; and

f) said system instrumentation driver selectively forwarding said system event notifications to said system management agent.

18. The method as set forth in claim **14**, wherein,

said method further comprises the step of (d) said system instrumentation driver issuing a command to said subsystem instrumentation interface commanding said subsystem instrumentation interface to initialize said subsystem instrumentation interface and cause said subsystem instrumentation handlers to be initialized;

said step (d) being performed at initialization time after said subsystem instrumentation interface has been allocated a working area of said subsystem instrumentation interface, but before any of said steps (a) through (c) are performed.

19. The method as set forth in claim **14**, wherein, said method further comprises the step of (d) said system instrumentation driver issuing a command to said subsystem instrumentation interface commanding said subsystem instrumentation interface to provide an estimate of a working area size requirement for said subsystem instrumentation interface; said step (d) being performed at preinitialization time before any of said steps (a) through (c) as well as initialization are performed.

20. An apparatus comprising:

a) a first non-volatile memory unit storing

a.1) a plurality of subsystem instrumentation handlers comprising set services for setting subsystem variables of subsystems implementing system management features to set values, and get services for getting current values of said subsystem variables;

a.2) a subsystem instrumentation interface for invoking said set or get services of said subsystem instrumentation handlers, and providing said set or get services with subsystem and subsystem variable identifications, in response to subsystem set or get commands having said subsystem and subsystem variable identifications;

b) an execution unit coupled to said first non-volatile memory unit for executing said subsystem instrumentation interface and said subsystem instrumentation handlers during operation.

21. The apparatus as set forth in claim **20**, wherein said subsystem instrumentation interface comprises:

(a.2.1) a first function for invoking appropriate ones of said set services of said subsystem instrumentation handlers, and providing said invoked set services of said subsystem instrumentation handlers with subsystem and subsystem variable identifications as well as set values; and

(a.2.2) a second function for invoking appropriate ones of said get services of said subsystem instrumentation handlers, and providing said invoked get services of said subsystem instrumentation handlers with subsystem and subsystem variable identifications.

22. The apparatus as set forth in claim **21**, wherein each of said first and second functions of said subsystem instrumentation interface is further equipped to invoke locking/unlocking services of said subsystem instrumentation handlers to achieve atomic results for subsystems supported by multiple subsystem instrumentation handlers.

23. The apparatus as set forth in claim **22**, wherein each of said first and second functions of said subsystem instrumentation interface is further equipped to performing checking against said subsystem instrumentation handlers to determine if they are locked before invoking their locking services.

24. The apparatus as set forth in claim **23**, wherein each of said first and second functions of said subsystem instrumentation interface is further equipped to logging said set or get commands for subsequent retries whenever at least one of subsystem instrumentation handler is locked while performing said checking for a set or get command.

25. The apparatus as set forth in claim **24**, wherein,

each of said first and second functions of said subsystem instrumentation interface logs said set or get commands by placing said set or get commands on a pending command queue;

said apparatus further comprises c) a third function for dequeuing said queued set or get commands responsive to detections of dequeuing events.

26. The apparatus as set forth in claim **21**, wherein said subsystem instrumentation interface further comprises:

(a.2.3) a third function for initializing a working area of said subsystem instrumentation interface with a plurality of working tables and allocating subsets of said working area of said subsystem instrumentation interface as working areas of said subsystem instrumentation handlers.

27. The apparatus as set forth in claim **21**, wherein said subsystem instrumentation interface further comprises:

(a.2.3) a third function for providing a working area size requirement for the subsystem instrumentation interface factoring into consideration how many subsystem instrumentation handlers are present and working area size requirements of the subsystem instrumentation handlers.

28. The apparatus as set forth in claim **20**, wherein each of said subsystem instrumentation handlers comprises:

(a.1.1) a first service for setting subsystem variables of a subsystem supported by the subsystem instrumentation handler to set values; and

(a.1.2) a second service for getting current values of subsystem variables of said subsystem supported by the subsystem instrumentation handler.

29. The apparatus as set forth in claim **28**, wherein each of said subsystem instrumentation handlers further comprises:

(a.1.3) a third service for locking or unlocking the subsystem instrumentation handler.

30. The apparatus as set forth in claim **28**, wherein each of said subsystem instrumentation handlers further comprises:

(a.1.3) a third service for initializing the subsystem instrumentation handler at initialization time.

31. The apparatus as set forth in claim **28**, wherein each of said subsystem instrumentation handlers further comprises:

(a.1.3) a third service for identifying the subsystem(s) supported by the subsystem instrumentation handler.

32. The apparatus as set forth in claim **28**, wherein each of said subsystem instrumentation handlers further comprises:

(a.1.3) a header comprising a predetermined identifier identifying the handler as a subsystem instrumentation handler, a handler name naming the subsystem instrumentation handler, a handler size of the subsystem instrumentation handler, a checksum for the subsystem instrumentation handler, and a working area size requirement of the subsystem instrumentation handler.

33. The apparatus as set forth in claim **20**, wherein said apparatus further comprises:

c) a second non-volatile memory unit storing a system management agent comprising logic for causing said set or get commands to be issued by said subsystem instrumentation interface during operation; and

d) a volatile memory unit for storing a copy of said system management agent during operation.

34. The apparatus as set forth in claim **33**, wherein,

said second non-volatile memory unit further stores a system instrumentation driver comprising logic for issuing set or get commands to said subsystem instrumentation interface during operation, thereby causing said subsystem instrumentation interface to issue said set or get commands to said subsystem instrumentation handlers; and

said volatile memory unit is further used for storing a copy of said subsystem instrumentation driver during operation.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO.	:	5,604,904
DATED	:	February 18, 1997
INVENTOR(S)	:	Vittal Kini

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the Abstract at [57] in line 15 delete "vadous" and insert --various--

In column 4 at line 63 delete "interlace" and insert --interface--

In column 5 at line 28 delete "vadable" and insert --variable--.

In column 5 at line 44 delete "vadous" and insert --various--

In column 9 at line 18 delete "vadous" and insert --various--

Signed and Sealed this

Twelfth Day of August, 1997

Attest:

[illegible]

BRUCE LEHMAN

Attesting Officer *Commissioner of Patents and Trademarks*